

Glacier inventory and recent glacier variations in the Andes of Chile, South America

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The result of the first satellite-derived inventory of glaciers and rock glaciers in Chile, using Landsat TM/ETM+ images spanning 2000–03 and ancillary data, is presented. Although Chilean glaciers are representatives of the Southern Andes, the inventory has remained incomplete until the present, with large gaps in the Altiplano, the Palena district and the periphery of the Patagonian Icefield. The existence of sparse glacier inventories achieved using different methods justifies the need of one single standardized format using a semi-automatic procedure.

Chilean glaciers cover $23\,641 \pm 1182 \text{ km}^2$, including about 3200 km^2 of both debris-covered glaciers and rock glaciers. Glacier distribution and physical attributes is not uniform as a result of latitudinal climate and elevation gradients, with most ice occurring in the Patagonian Andes. In the desert Andes ($17^{\circ}30'–32^{\circ} \text{ S}$) and the central Andes ($32–36^{\circ} \text{ S}$), we find 1% and 4%, respectively, of the country's glacier cover. In the lakes and Palena districts ($36–46^{\circ} \text{ S}$), glaciers increase in size, accounting for about 7% of the glacier area, while in Patagonia and Tierra del Fuego ($46–56^{\circ} \text{ S}$) 88% of the glacierized area is drained by large outlet glaciers. 66 major calving glaciers in Patagonia cover $\sim 12\,138 \text{ km}^2$. Although less than 1% of the Chilean glacierized area is found in the Altiplano ($17^{\circ}30'–19^{\circ}45' \text{ S}$), the large glacierized area south of 25° S represents nearly 80% of the glacierized area of the entire Southern Andes.

Glacier outlines, across all glacierized regions and size classes, updated to 2015 using Landsat 8 images for 98 large glacier complexes, indicate a generalized decline in areal extent affecting mostly clean-ice glaciers. The recession in Patagonia is the largest in the Chilean Andes ($-0.53 \text{ km}^2 \text{ a}^{-1}$). A large number of glacierets along the country, smaller than 0.05 km^2 , have mostly disappeared ($\sim 265 \text{ km}^2$), whereas debris-covered glaciers and rock glaciers in the desert and central Andes appear nearly unchanged in their extent.

The uneven recession rates observed along the country are explained by the contrasting response of debris-covered glaciers in the desert and central Andes and calving glaciers in Patagonia. Glacier attributes estimated by this new inventory provide valuable insights into spatial patterns of mass loss for assessing future glacier changes in response to climate change.